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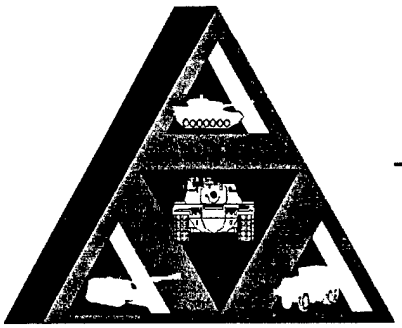

Technical Report

No: TR-13690

Alaska Propylene Glycol Field Demonstration

March 1997

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	MARCH 1997	Final, June 1995 to January 1997

4. TITLE AND SUBTITLE

Alaska Propylene Glycol Antifreeze Demonstration

5. FUNDING NUMBERS

6. AUTHOR(S)

Dwayne Davis

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

U.S. ARMY TANK-AUTOMOTIVE RD&E CENTER (TARDEC)
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8. PERFORMING ORGANIZATION REPORT NUMBER

TARDEC-TR 13690

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

CDR DEFENSE SUPPLY CENTER RICHMOND
ATTN DSCR VBB
8000 JEFFERSON DAVIS HIGHWAY
RICHMOND VA 23297-5000

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT

Distribution unlimited; approved for public release

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

The use of propylene glycol (PG) base antifreeze in military vehicles is being evaluated. Following a successful field demonstration of a formulated Propylene Glycol Antifreese (PGAF) at Ft. Bliss TX, a follow-on demonstration was conducted at Ft. Wainwright near Fairbanks AK. This demonstration was to assess the performance of PGAF in cold temperature environments. Tactical vehicles were used for this demonstration.

14. SUBJECT TERMS

Propylene Glycol, Environmentally Friendly Antifreeze, MIL-A-46153, Military Antifreeze

15. NUMBER OF PAGES

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UNLIMITED

ALASKA PROPYLENE GLYCOL ANTIFREEZE DEMONSTRATION

I. INTRODUCTION

Background

The completion of the Propylene Glycol Antifreeze (PGA) field demonstration in Alaska marks the end of a Mobility Technology Center-Belvoir (MTCB) investigation resourced by the Defense Supply Center Richmond to develop a nonhazardous or less hazardous alternative antifreeze for the currently specified ethylene glycol antifreeze (EGA) utilized by the Department of Defense.

The military need for an alternative antifreeze was established because of state and federal legislation placing additional restrictions on handling, use, and disposal of EGA base antifreeze. The additional restrictions are due to EGA's inherent high toxicity toward mammals. For example, EGA is federally regulated by the Occupational Safety and Health Administration (OSHA) based on Threshold Limit Values (TLV's) for hazardous chemical substances in workroom air. In 1991, EGA was added to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) toxic air pollutants list from the 1990 Clean Air Act. This act required users to report spills of one (1) pound or more. The one pound limit was changed to 5000 pounds in July 1995 which alleviated most concerns of organizations using small to moderate amounts of EGA. However, the addition of EGA to the CERCLA list was a significant impetus for a less toxic, alternative antifreeze and is still of concern for organizations using and disposing of large quantities of EGA.

The anticipated future state and federal regulations will invariably increase operational costs of vehicles/equipment that employ automotive EGA. Having a substitute PGA available for use will help decrease the number of problems and offer an alternative for agencies interested in reducing environmental risks while increasing worker safety.

Objective

The objective of this effort was to demonstrate in a military environment the cold weather performance capabilities of a candidate PGA formulation previously developed and successfully evaluated under hot to temperate weather conditions.

II. INVESTIGATION

Approach

The results of U.S. Army TACOM Technical Report #13644[(1)][1] confirmed PGA could perform satisfactorily in U.S. Army combat and tactical vehicles without any modifications to vehicles or customary vehicle maintenance practices. During the previous investigation, eleven (11) combat/tactical vehicles ranging from Bradley Fighting Vehicles to 5-Ton Trucks to 1¼-Ton Cargo Trucks were filled with a candidate PGA. The vehicles, along with control vehicles using the MIL-A-46153 EGA were operated for one (1) year at Ft Bliss TX under temperate to hot weather conditions. At the completion of the test, no coolant related vehicle performance abnormalities were observed or noted with test vehicles containing the PGA.

To further demonstrate PGA's military vehicle performance for all climatic environments, the candidate PGA formulation whose performance capabilities were successfully shown at Ft Bliss TX was similarly evaluated in U.S. Army tactical vehicles at Ft Wainwright, Fairbanks AK. The Fairbanks' average ambient temperature during the months from November through February ranges from zero (0) degrees to -15°F[(2)]. The 47th Engineer Company Motor Pool of Ft Wainwright volunteered twelve (12) tactical vehicles for a one year demonstration. The test and control vehicles are listed in Table 1. The average vehicle age was approximately 12 years. All of the vehicles had cast iron water pumps, engine blocks, and cylinder heads, and brass/copper radiators. A few vehicles utilized aluminum alloy thermostat housings. Eight (8) test vehicles were filled with the candidate PGA. The remaining four (4) vehicles were used as control vehicles, with each vehicle filled with MIL-A-11755 EGA (Arctic Antifreeze)[(3)].

Preparation of vehicles included the draining and flushing of vehicle cooling systems with tap water. The use of a commercial cooling system chemical flush was performed on vehicles containing particularly rusty coolants. Only three (3) vehicles required the use of a chemical flush. The original vehicle coolant had been MIL-A-46153[(4)]. The freeze protection levels of the original antifreeze ranged between -50°F and -55°F. The test PGA was prepared using the undyed, candidate propylene glycol with inhibitors diluted to a 60%:40% mixture (i.e., 60% PGA: 40% water) giving a freeze protection level of -56°F. The control EGA (i.e., MIL-A-11755) was a prediluted antifreeze, 65% by volume ethylene glycol and having a freeze point of approximately -90°F. The motor pool was provided with additional 55-gallon drums of the control EGA and the test PGA for demonstration vehicles requiring "make-up" antifreeze for "topping-off".

The determination of the performance capabilities of the PGA was accomplished in an identical fashion as had occurred during the previous Ft. Bliss demonstration. The process

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[1] Superscript numbers between parenthesis are for references found in section VI of the report.

involved comparing selected antifreeze properties, reviewing 47th Engineer Company Motor Pool test vehicle maintenance reports, and monitoring vehicle operator and mechanic field experience with comparisons to the MIL-A-11755 antifreeze. The selected antifreeze properties included pH, freeze point, acid buffer capacity or reserve alkalinity (RA), and corrosion trace metal content. A small antifreeze sample (≈250mL) was collected and analyzed quarterly from each test vehicle. In addition, motor pool vehicle maintenance reports were examined, and test vehicle operators and mechanics were interviewed each quarter. The test plan followed during this demonstration is provided in Appendix A.

Results and Discussion

Examination of the mileage and hours data in Table 2 show vehicle usage during this demonstration was relatively low when compared to commercial vehicle usage. For example, Cummins Engine Company, Caterpillar Incorporated, and Detroit Diesel Corporation (the manufacturers for most military combat/tactical vehicles) recommend average antifreeze change intervals of 250 hours per month (≈10,000 miles per month), 125 hours per month (≈5,000-6,000 miles per month), and 167 hours per month (≈8,333 miles per month), respectively.

The relatively low mileages and operating hours military vehicles accumulate are typical of peacetime operations and illustrate the demanding "stop and start" vehicle operation encountered with the majority of the military vehicles in service. This type of vehicle usage is especially demanding in sub-zero weather where engines are started cold and are usually idled for long periods before driving. In extreme cold weather, vehicles are idled continuously. For example during February 1996, the entire motor pool participated in a routine field exercise. The field exercise was a regular part of the motor pool mission objectives and was conducted to practice the motor pool's extreme weather operational skills. The field exercise was conducted in the northern interior, the Yukon area of Alaska which is a two hour drive from Ft Wainwright. The exercise was conducted for fifteen (15) days and included all operational 47th Engineer Company vehicles, which included all twelve (12) of the demonstration control and test vehicles. The ambient temperatures during the exercise averaged -40°F and the windchill ranged from -80°F to -100°F. All vehicles had to idle 24 hours a day to prevent vehicle fluids from freezing and restart problems. During the extreme cold conditions, continuous vehicle idling is a standard Army practice. None of EGA control or PGA test vehicles experienced any engine failures or antifreeze related problems during this cold weather excursion.

Results of the antifreeze sample analyses that were taken quarterly are shown in Tables 2 through 8. Tables 3 and 4 give the pH, RA, and Freeze Point (FP) results on the PGA and EGA samples whereas Tables 5 and 6 give the trace metal. analyses on the same PGA and EGA samples respectively; Fe being Iron, Pb being Lead, Cu being Copper, and Al being Aluminum. The structure of these Tables (i.e., Tables 3-6) show the Vehicle Number across the top followed by the particular test being performed. For example, Table 3 lists the pH values for Vehicle 317 starting with "pH-BD" and ending with "pH-12". At the footnote states, the " -BD" designation represents the pH determined on the coolant in that vehicle before initiation of the field

demonstration. The "-BVI" designation represents the pH determined on the PGA before it was introduced into Vehicle 317. The "-0" designation represents the pH determined on the PGA after introduced into Vehicle 317 and allowed to circulate within the engine for approximately 15 minutes. This sample represents the actual initial baseline value for the vehicle. The "-3, -6, -9, and -12" designations represent pH values obtained on the 3 month, 6 month, 9 month, and 12 month quarterly samples, respectively. This same methodology applies to Tables 4-6.

The results on Table 3 show significant fluctuations in the freeze point (FP) values of PGA from test vehicles 130, 230, and 354. For vehicles 130 and 230, the fluctuations were presumably caused by cooling system leaks. The gradual increase of FP is indicative of small, chronic cooling system leaks. In Table 3, the decrease in the Reserve Alkalinity (RA) values of vehicles 130 and 230 also suggest water dilution caused by leaks. After approximately three (3) months of service, the demonstration vehicle samples began to show visual signs of water and/or foreign antifreeze contamination (i.e., not the test or control antifreeze). Comparing Tables 7 and 8, the color differences of the starting and final samples suggest PGA test vehicles 317 and 354 experienced the most contamination, with significant amounts of presumably MIL-A-46153 EGA having been inadvertently added to their systems by motor pool personnel. For example, motor pool personnel will perform a "topping off" operation to correct low cooling system antifreeze levels. In Table 3, the large increase in the RA value of vehicle 317 suggest that MIL-A-46153 was added as new MIL-A-46153 has a very large RA value. For vehicle 354, the large RA increase followed by decreases in the RA and FP suggest both MIL-A-46153 additions and cooling system leaks.

The remaining PGA test vehicles appear to have been contaminated to a lesser degree with foreign EGA. For example, vehicles 130, 230, 330 and 432 PGA showed no color changes other than the characteristic olive color discoloration that commonly occurs with undyed PGA during normal service. The faint green color of PGA samples from vehicles 402 and 404 suggests these samples were only slightly contaminated. Because of the distinct color differences of new MIL-A-46153 (blue-green) and new MIL-A-11755 (fluorescent orange), similar conclusions concerning foreign antifreeze contamination can be inferred about the EGA control vehicles. For example, other than the presence of the corrosion inhibitor Mercaptobenzothiazole occasionally present in new MIL-A-11755[5], the EGA in vehicles 319 and 132 appear to have not been contaminated; however, vehicle 336 was obviously contaminated. Vehicle HQ6 was removed from service after seven (7) months of service for repair of a damaged radiator fan shroud. The damage was attributed to wear and was not coolant related. A sample was not collected prior to the vehicle's removal. After eight (8) months of service, the vehicle 317 developed radiator leaks and the vehicle would not reach its normal operating temperature. It was temporarily removed from service for inspection and repair of its radiator and electronic temperature sensors. After examination, the radiator leaks were attributed to non-coolant related mechanical fatigue. The low operating temperature was caused by a low antifreeze level, the result of a leaking radiator. The radiator was repaired and vehicle 317 was subsequently returned to service.

Despite the small contamination found in some of PGA vehicle samples, the majority of these samples indicated satisfactory performance during the demonstration. As such, no vehicle failures or antifreeze related problems were recorded or observed by 47th Engineer Company Motor Pool personnel for vehicles containing the test PGA. In addition to the motor pool personnel experiences, ARCO Chemical Company examined depletion rates of the test PGA's additive ingredients by analysis of the quarterly antifreeze samples. ARCO concluded the depletion rates were normal. The antifreeze trace metal data of Tables 5 and 6 are indicative of normal depletion rates found with vehicle usage.

III. CONCLUSIONS

The PGA was found to be fully capable of performing in an extreme cold-weather, military environment. The use of PGA in military vehicles, under extreme cold-weather conditions, is acceptable without any elaborate modifications to vehicles or current vehicle maintenance practices. The PGA gave performance equivalent to the currently required MIL-A-11755 EGA.

Conventionally formulated PGA and EGA can be mixed in a field environment without the occurrence of any incompatibility or deleterious effects being evidenced.

IV. RECOMMENDATIONS

A commercial item description (CID) has been developed to allow the purchase of commercial PGA or EGA for both military and federal agencies. The new CID has multi-engine performance capabilities to eliminate user confusion sometimes associated with single application antifreeze standards by including both heavy duty (i.e., large trucks, buses, etc.) and light duty (i.e., cars, small trucks, etc.) antifreeze performance requirements.

The new CID A-A-52624 Antifreeze Multi Engine Type is provided under Appendix B. It is recommended this new CID be adopted by the Army and other DOD agencies. The success of this field demonstration and the previously completed demonstration at Ft. Bliss[1] coupled with recent investigations and testing by industry that clearly demonstrate the successful performance of PGA [6],[7],[8],[9],[10],[11],[12] provide more than ample justification for adoption of this CID.

V. ACKNOWLEDGMENTS

The writer wishes to thank the following people for their assistance in the successful completion of this program; the 47th Engineer Company Motor Pool of Ft Wainwright AK, Motor Sgt David K. Garrison; ARCO Chemical Company, Mr. James P. Greaney; and Sgt Donna Rutkowski, who was formally of this Center.

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Table 1
Alaska Demonstration Test Vehicles

Vehicle	Admin#	Model-Mfr Year	Engine Make
Met Tractor Trk	317	M920-1979	Cummins NTC-400
Met Tractor Trk	319	M920-1979	Cummins NTC-400
5-Ton Dump Trk	132	M929-1985	Cummins NHC-250
5-Ton Dump Trk	130	M929-1985	Cummins NHC-250
5-Ton Dump Trk	230	M929-1985	Cummins NHC-250
5-Ton Cargo Trk Fuel Tank	330	M930-1977	Cummins NHC-250
5-Ton Wrecker Trk	432	M936WW-1985	Cummins NHC-250
¼-Ton Util Cargo Trk	HQ6	M998-1985	GM 6.2L Diesel
1¼-Ton Util Cargo Trk	402	M998-1984	GM 6.2L Diesel
1¼-Ton Cargo Trk	404	SEQENG/1978	Chevrolet V-TYPE 8-CYL Diesel
Bulldozer	354	D7GWROPS-1988	Caterpillar 3306
Loader Scooper	336	MW24-1984	JI Case 4-CYL Turbo Diesel

Table 2.
Accumulated Vehicle Mileage & Hours Data

Vehicle (Antifreeze)	Dec96 Final mi/hrs	Dec95 Initial mi/hrs	Total Accumulated mi/hrs
Met Tractor Trk 317(PGA)	6730mi/na	4126mi/na	2604mi/na
5-Ton Dump Trk 130(PGA)	14180mi/16hrs	12708mi/16hrs	1472/0hrs
5-Ton Dump Trk 230(PGA)	2572mi/43hrs	1845mi/43hrs	727/0hrs
5-Ton Trk Fueler 330(PGA)	1305mi/12hrs	1300mi/12hrs	5mi/0hrs
5-Ton Wrecker Trk 432(PGA)	18399mi/1503hrs	15414mi/1276hrs	2985mi/227hrs
1¼-Ton Utility Cargo Trk 402(PGA)	6966mi/na	6826mi/na	140/na
1¼-Ton Cargo Trk 404(PGA)	9081mi/na	6392mi/na	2689mi/na
Bulldozer 354(PGA)	na/2772hrs	na/2441hrs	na/331hrs
Met Tractor Trk 319(EGA)	5307mi/na	2344mi/na	2963mi/na
5-Ton Dump Trk 132(EGA)	17289mi/1287hrs	16715mi/1246hrs	574mi/41hrs
1¼-Ton Utility Cargo Trk HQ6(EGA)	na	11423mi/na	66mi/na
Loader Scp 336(EGA)	na/392hrs	na/230hrs	na/162h

Table 3
pH, RA, and FP Values for PGA Test Vehicles

Veh #	**317**	**130**	**230**	**330**	**432**	**402**	**404**	**354**
pH-BD[1]	7.9	7.6	8.6	7.9	na[2]	7.5	8.2	8.0
pH-BVI[3]	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3
pH-0	9.3	8.3	7.6	9.2	9.2	9.1	9.2	9.2
pH-3	8.9	8.4	9.1	8.9	8.9	8.9	9.0	7.3
pH-6	8.7	8.5	9.0	8.3	8.6	8.6	8.6	6.7
pH-9	7.5	8.5	8.6	8.7	8.7	8.2	8.0	7.7
pH-12	7.4	8.2	8.3	8.5	8.5	8.1	7.8	7.4
RA-BD	13.6mL	14.8mL	3.6mL	11.4mL	na	15.2mL	12.8mL	9.9mL
RA-BVI	9.1mL	9.1mL	9.1mL	9.1mL	9.1mL	9.1mL	9.1mL	9.1mL
RA-0	7.5mL	7.5mL	7.6mL	7.4mL	7.5mL	7.6mL	7.2mL	7.6mL
RA-3	7.2mL	7.8mL	7.6mL	6.9mL	7.3mL	7.5mL	7.0mL	18.1mL
RA-6	6.6mL	6.8mL	6.5mL	6.7mL	7.0mL	7.4mL	6.9mL	18.1mL
RA-9	15.6mL	6.0mL	5.5mL	7.0mL	7.2mL	8.8mL	9.0mL	13.1mL
RA-12	15.9mL	6.7mL	6.0mL	7.5mL	7.5mL	8.7mL	9.0mL	12.4mL
FP-BD	-40 F	<-60 F	+20 F	-30 F	na	<-60 F	-50 F	-20 F
FP-BVI	<-50 F	<-50 F	<-50 F	<-50F	<-50F	<-50F	<-50 F	<-50 F
FP-0	<-50 F	-50 F	<-50 F	-50 F	<-50 F	<-50 F	-50 F	-50 F
FP-3	<-50 F	<-50 F	<-50 F	-50 F	-50 F	- 50 F	-50 F	<-50 F
FP-6	<-50 F	-50 F	-42 F	-46 F	<-50 F	<-50 F	-48 F	<-50 F
FP-9	<-50 F	-25 F	-15 F	<-50 F	<-50 F	<-50 F	<-50 F	-25 F
FP-12	-47 F	-32 F	-20 F	-50 F	<-50 F	<-50 F	<-50 F	-41 F

[1] BD designation identifies sample taken before start of demonstration.
[2] Samples were not available.
[3] BVI designation identifies sample to be introduced into vehicle.

Table 4
pH, RA, and FP Values for EGA Control Vehicles

Vehicle #	**319**	**132**	**HQ6**	**336**
pH-BD	7.6	7.5	7.5	7.6
pH-BVI	7.4	7.4	7.4	7.4
pH-0	7.6	9.3	7.6	7.7
pH-3	7.6	9.3	7.6	7.7
pH-6	7.3	7.4	7.8	6.9
pH-9	7.6	7.6	na	7.6
pH-12	7.4	7.5	na	7.3
RA-BD	16.0mL	1.6.6mL	14.8mL	14.4mL
RA-BVI	17.4mL	17.4mL	17.4mL	17.4mL
RA-0	14.2mL	13.8mL	15.2mL	12.9mL
RA-3	13.2mL	14.2mL	11.6mL	14.6mL
RA-6	12.1mL	14.0mL	11.0mL	14.5mL
RA-9	12.5mL	14.2mL	na	14.6mL
RA-12	12.9mL	14.3mL	na	16.6mL
FP-BD	<-60 F	<-60 F	<-60 F	-60 F
FP-BVI	<-60 F	<-60 F	<-60 F	<-60 F
FP-0	<-60 F	<-60 F	<-60 F	-60 F
FP-3	<-60 F	<-60 F	<-60 F	-60 F
FP-6	<-60 F	<-60 F	<-60 F	-58 F
FP-9	<-60 F	<-60 F	na	-57 F
FP-12	<-60 F	-60 F	na	<-60 F

Table 5
Trace Metal (ppm) Values for PGA Test Vehicles

Veh #	317	130	230	330	432	402	404	354
Fe-BD [1]	1.2	na [2]	2.6	2.4	na	6.8	<0.5	<0.5
Fe-0 [3]	2.6	3.4	<0.5	0.8	1.8	<0.5	<0.5	<0.5
Fe-3	7.8	8.7	7.4	8.1	7.3	<0.5	<0.5	6.0
Fe-6	6.0	7.0	<0.5	na	5.0	<0.5	<0.5	na
Fe-9	13	8.7	5.8	6.7	7.2	1.2	<0.5	<0.5
Fe-12	7.6	3.8	23	16	14	1.8	1.0	3.8
Pb-BD	<5	na	<5	<5	na	<5	<5	,5
Pb-0	<5	<5	<5	<5	<5	<5	<5	<5
Pb-3	>5	>5	>5	6.0	<5	<5	6.8	5.0
Pb-6	<5	7.0	<5	na	<5	<5	<5	na
Pb-9	11	9.9	<5	14	<5	<5	<5	<5
Pb-12	5.4	4.0	<5	5.8	7.6	6.4	10.0	7.2
Cu-BD	<0.5	<0.5	<0.5	<0.5	na	<0.5	<0.5	<0.5
Cu-0	4.9	<0.5	<0.5	<0.5	<0.5	<0.5	6.4	<0.5
Cu-3	<0.5	<0.5	<0.5	<0.5	4.5	7.2	<0.5	<0.5
Cu-6	0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Cu-9	<0.5	<0.5	<0.5	<0.5	0.8	<0.5	<0.5	<0.5
Cu-12	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	2.6	<0.5
Al-BD	<5	<5	<5	<5	na	<5	<5	<5
Al-0	6.3	<5	<5	<5	<5	<5	<5	<5
Al-3	<5	<5	<5	<5	5.5	6.0	<5	<5
Al-6	<5	<5	<5	<5	<5	<5	<5	<5
Al-9	>5	>5	>5	>5	>5	>5	>5	>5
Al-12	>5	>5	>5	>5	>5	>5	>5	>5

[1] BD designation identifies sample to be taken before start of demonstration.
[2] Samples were not available.
[3] "-0" designation identifies sample at start of demonstration (i.e., the baseline).

Table 6
Trace Metal (ppm) Values for EGA Control Vehicles

Vehicle #	**319**	**132**	**HQ6**	**336**
Fe-BD [1]	200	28	31	<0.5
Fe-0 [3]	na[2]	<0.5	5.0	<0.5
Fe-3	na	7.2	9.1	<0.5
Fe-6	na	5.2	19	<0.5
Fe-9	10	3.3	na	0.6
Fe-12	4.6	1.0	na	2.0
Pb-BD	<5	na	<5	<5
Pb-0	na	3.4	12	<5
Pb-6	<5	70	na	<5
Pb-9	11	13	na	8.1
Pb-12	7.8	7	na	7.4
Cu-BD	0.6	<.5	<0.5	<0.5
Cu-0	<0.5	<0.5	<0.5	<0.5
Cu-3	<0.5	<0.5	<0.5	<0.5
Cu-6	<0.5	<0.5	6.4	<0.5
Cu-9	<0.5	<0.5	na	<0.5
Cu-12	<0.5	<0.5	na	<0.5
Al-BD	<5	<5	<5	<5
Al-0	<5	<5	<5	<5
Al-3	<5	<5	<5	<5
Al-6	<5	<5	<5	<5
Al-9	<5	<5	na	<5
Al-12	<5	<5	na	<5

[1] BD designation identifies sample to be taken before start of demonstration.
[2] Samples were not available.
[3] "0" designation identifies sample at start of demonstration (i.e., the baseline).

Table 7
Sample Appearances at Start of Demonstration (i.e., 0 months)

Veh Number [1]	Appearance of Sample
317 (PGA)	Water-white, no color, translucent appearance, no visible debris
130 (PGA)	Same as above
230 (PGA)	Same as above
330 (PGA)	Same as above
432 (PGA)	Same as above
402 (PGA)	Same as above
404 (PGA)	Same as above
354 (PGA)	Same as above
319 (EGA)	Bright orange color, translucent appearance, no debris, but moderate amounts of a white precipitate [2] upon setting
132 (EGA)	Same as above
HQ6 (EGA)	Same as above
336 (EGA)	Same as above

[1] PGA designates the "test" vehicles whereas EGA designates the "control vehicles.
[2] Benzothiazyl disulfide is formed by the oxidation of the Mercaptobenzothiazole (MBT) corrosion inhibitor in the arctic antifreeze (MIL-A-11755). There is no significant deleterious effects associated with this precipitate.

Table 8
Sample Appearances at End of Demonstration (i.e., 12 months)

Veh #	Appearance of Sample
317 (PGA)	Blue-green color, murky appearance with light amounts of sediment upon setting
130 (PGA)	Olive color, very murky appearance with light to moderate amounts of sediment upon setting
230 (PGA)	Olive color, clear appearance with moderate amounts of sediment upon setting
330 (PGA)	Olive color, murky appearance with light amounts of sediment upon setting
432 (PGA)	Olive color, clear appearance with moderate amounts of sediment upon setting
402 (PGA)	Pale-green color, clear appearance with very light amounts of sediment upon setting
404 (PGA)	Same as above
354 (PGA)	Green color, clear appearance with very light amounts of sediment upon setting
319 (EGA)	Orange color, clear appearance with light amounts of sediment upon setting
132 (EGA)	Orange color, white precipitate suspended throughout sample with light amounts of sediment upon setting
HQ6 (EGA)	Removed from the testing program on 27 August 1996
336 (EGA)	Black-green color, very murky appearance with light amounts of sediment upon setting

APPENDIX A

PROPYLENE GLYCOL ANTIFREEZE ALASKA FIELD DEMONSTRATION TEST PLAN

OBJECTIVE

To demonstrate acceptable field performance of a propylene glycol base military-type antifreeze (PGAF) when used in combat/tactical and light duty vehicles operated in extreme cold (arctic) environment. Successful completion of this demonstration will result in replacing both MIL-A-46153 military antifreeze and MIL-A-11755 arctic antifreeze, ethylene glycol base military-type antifreezes (EGAF).

A cooperative effort between the Mobility Technology Center-Belvoir (**MTC-B**) and the Defense General Supply Center's (**DGSC**) Hazardous Waste Minimization Program was begun in April 1991 to develop a fully formulated PGAF specification which could be used as a less toxic replacement for the current EGAF meeting MIL-A-46153 and MIL-A-11755 requirements. The need for a less toxic antifreeze was established because of ever increasing state and federal legislation placing additional restrictions concerning the handling of EGAF. Such restrictions are adding to the cost of operation of military installations. Having a PGAF specification will help reduce significantly the number of problems associated with EGAF.

SCOPE

A non-impact field demonstration is to be conducted to evaluate the performance of the candidate PGAF. The methodology used in the PGAF field demonstration on-going at Ft. Bliss TX will be followed.

TECHNICAL APPROACH

This demonstration will focus on testing the PGAF previously developed and currently being field tested at Ft. Bliss, TX, in an arctic environment. This testing will consist of subjecting the PGAF formulation to low ambient temperatures in Alaska and compare its performance to the requirements of MIL-A-11755 Arctic-Type antifreeze. The typical characteristics of the PGAF and the EGAF are listed in Table 1. The performance qualities of the PGAF will be determined by monitoring the antifreeze and cooling systems of vehicles being operated under their normal mission and duty cycles. In addition, the engine oil of the test vehicles will also be examined. The resultant performance of designated test vehicles (i.e., those containing PGAF) will be compared to designated control vehicles (i.e., those containing EGAF). Those parameters being monitored will include:

- Mileage being accumulated
- Hours of engine operation
- Results of quarterly antifreeze sample analyses
- Vehicle performance/driver observations
- Cooling system component inspections
- Results of quarterly engine oil wear metal analyses

TABLE 1. Test Sample Characteristics
50/50 mixtures with water

	PGAF	EGAF
pH	10.2	7.8
Reserve Alkalinity	11.0mL	12.9mL
Freeze Point	-27°F	-32°F

This field demonstration is to be conducted on a non-interference basis; for example, the examination will not cause any disruption to the mission requirements of the units participating in the demonstration.

RESPONSIBILITIES

FOR MTC-B:

- Provide the test antifreeze (i.e., PGAF and the control EGAF, MIL-A-11755 military antifreeze). A supply of makeup antifreeze, both PGAF and EGAF, will be provided for use during the test.

- Prepare vehicles for tests and incur the costs of labor and materials required for cleaning each test vehicle cooling system with a chemical flush.

- Before the initial filling of test vehicles, collect 10-oz samples of the original antifreeze and 3-oz samples of the original engine oil.

- After the initial fill, conduct visual cooling system inspections of each test vehicle and take 10-oz samples of the antifreeze and 3-oz samples of the engine oil for analysis from each test vehicle. Thereafter, 10-oz samples will be taken approximately every three months until the end of the demonstration. The field unit personnel will be notified before each 3-month visit. Each visit will be conducted only when convenient for personnel so as not to interfere with the field unit's mission.

- The test vehicle samples taken quarterly will be tested for the following:

  Antifreeze-
  - pH, ASTM D1287
  - Reserve alkalinity (RA), ASTM D1121
  - Freeze point, ASTM D3321
  - Lead, Aluminum, Iron, and Copper concentration

  Engine Oil-
  - Iron, Copper, Aluminum, Chromium, Boron concentration

FOR FIELD UNIT(s):

- Assist in the preparation of vehicles for tests. Cost of labor and materials will be reimbursed by MTC-B.

- Provide 25 high-mileage vehicles ranging from light duty to combat/tactical. Including Army, Air Force, and Army National Guard vehicles. Vehicle types should be distributed as follows:

    - Five (5) Administrative Vehicles
    - Five (5) 5-Ton Truck
    - Five (5) Commercial Utility Cargo Vehicles(CUCV)
    - Five (5) High Mobility Multipurpose Wheeled Vehicles (HMMWV)
    - Five (5) Track Vehicles

- Ensure that the test vehicles are operated in normal service during the duration of this test.

TEST VEHICLE PREPARATION

- The cooling system of each test vehicle will be drained and flushed thoroughly with water. A chemical cooling system flush will be used for all systems regardless of flush water cleanliness to establish an equal baseline among the vehicles. MTC-B will provide the cleaner.

- All suspect cooling system hoses will be replaced with new hoses. MTC-B will reimburse the field unit for the cost of the replacement hoses.

- The field unit will provide identification tags for each test vehicle. The tags will have the vehicle bumper number and a note alerting personnel of the ongoing field test.

FIELD TEST

- During the test, if an accident or other unforeseen event makes it necessary to use makeup antifreeze, the makeup test antifreeze provided will be used. If the field unit personnel are not able to use the makeup antifreeze or accidentally contaminate the test antifreeze, such actions will need to be documented. For example, how much makeup antifreeze was used, why was makeup antifreeze needed, and what was used as makeup antifreeze (e.g., water, MIL-A-11755, etc.). In addition, when mishaps occur that cause a test vehicle to be removed from service briefly document the occurrence (e.g., how, why, what, and when).

- At the conclusion of this test MTC-B will take 1-gallon samples from each test vehicle. The remainder of the test antifreeze will be disposed of by the field unit as they normally dispose their used antifreeze. MTC-B will reimburse the field unit for new MIL-A-11755 antifreeze to replace the spent test antifreeze for each test vehicle. In addition, the field unit will remove the radiators and water pumps of six (6) selected test vehicles for examination purposes. MTC-B will reimburse the field unit for the cost of new replacement radiators and pumps and labor.

APPENDIX B

NOT MEASUREMENT SENSITIVE

A-A-52624
February 6, 1997
SUPERSEDING
See 7.3

COMMERCIAL ITEM DESCRIPTION

ANTIFREEZE, MULTI ENGINE TYPE

The General Services Administration has authorized the use of this commercial item description for all federal agencies.

1. SCOPE. This commercial item description (CID) covers the requirements for automotive engine, ethylene glycol or propylene glycol antifreeze suitable for use in all administrative vehicles, construction vehicles and equipment, and all military ground combat and tactical equipment/vehicles.

2. CLASSIFICATION.

2.1 Antifreeze types. The antifreezes will be the following types:

Antifreeze Type	Glycol Base	Glycol Level
I	Ethylene Glycol	Concentrated (100%)
IP	Ethylene Glycol	Prediluted 60%
II	Propylene Glycol	Concentrated (100%)

Beneficial comments, recommendations, additions, deletions, clarifications, etc. and any data which may improve this document should be sent to: U.S. Army Tank-automotive and Armaments Command, ATTN: AMSTA-TR-E/BLUE, Warren, MI 48397-5000

AMSC N/A FSC 6850

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

3. SALIENT CHARACTERISTICS.

3.1 Material. The antifreeze shall meet all the requirements specified herein.

3.2 Requirements.

3.2.1 Basic performance requirements. Type I antifreeze shall meet all the requirements of ASTM D 3306 and ASTM D 4985. Type IP antifreeze shall meet all the requirements of ASTM D 4656 and ASTM D 5345. Type II antifreeze shall meet all the requirements of ASTM D 5216.

3.2.2 Additional chemical requirements. Types I and II antifreezes shall have a minimum nitrite concentration of 2400 parts per million (ppm) (as NO_2^-) when tested in accordance with ASTM D 4327 or a combined total of at least 1560 ppm of nitrite (as NO_2^-) plus molybdate (as MoO_4^{-2}) with a minimum of 600 ppm of nitrite or minimum of 600 ppm molybdate, when tested in accordance with ASTM D 5827. Type IP antifreeze shall have a minimum nitrite concentration of 1200 ppm (as NO_2^-) when tested in accordance with ASTM D 5827 or a combined total of at least 780 ppm nitrite (NO_2^-) plus molybdate (as MO_4^{-2}) with a minimum of 300 ppm of nitrite or 300 ppm of molybdate, when tested in accordance with ASTM D 5827. Type IP antifreeze shall have a 60% by volume minimum ethylene glycol concentration and must have a maximum freeze point of -62°F (-52°C) when tested in accordance with ASTM D 1177. Types I, IP, and II antifreezes shall have a maximum silicon concentration of 250 ppm when tested in accordance with ASTM D 5185, except that aqueous standards and distilled water shall be used as the sample solvent and blank in place of the petroleum solvent prescribed in ASTM D 5185.

3.2.3 Compatibility requirements. The antifreeze shall pass the compatibility test specified herein.

3.2.3.1 Compatibility test. The following compatibility test shall be performed: A sample of Type I or Type II antifreeze and a sample of reference fluid conforming to ASTM D 3585. Prepare a 60% by volume solution of each with corrosive water conforming to ASTM D 1384. For Type IP antifreeze, do not dilute sample further, use as is. In a suitable glass stoppered, 100 milliliters (mL) graduated cylinder, combine 50 mL of the 60% diluted test antifreeze solution and 50 mL of the diluted 60% reference fluid solution conforming to ASTM D 3585. Thoroughly mix the resultant solution. Allow this solution to stand in a lighted area, undisturbed at room temperature, for 24 hours. After 24 hours, observe the solution for any precipitate, phase separation, turbidity, or cloudiness. For an additional 24 hours, place the stoppered solution in an oven at 60°C. After 24 hours, remove the solution from the oven and again observe the solution for any precipitate, phase separation, turbidity, or cloudiness. Report observations. The observation of excessive precipitates or large phase separations constitutes failure of this test. Slight turbidity, cloudiness, and minor amounts of precipitates and/or small phase separations due to antifoam agents of less than 0.5% of the total volume of solution are permissible.

3.2.4 Storage stability requirements. The antifreeze shall pass the storage stability test specified herein.

3.2.4.1 Storage stability test. Types I and IP, and Type II antifreezes shall be tested for storage stability as follows: Place 100 mL of antifreeze in a suitable glass stoppered, 100-mL graduated cylinder. Allow this solution to stand in a lighted area, at room temperature, undisturbed for 24 hours. After 24 hours, observe the solution for any precipitate, phase separation, turbidity, or cloudiness. For an additional 24 hours, place the stoppered solution in an oven at 60°C. After 24 hours, remove the solution from the oven and again observe the solution for any precipitate, phase separation, turbidity, or cloudiness. Report observations. The observation of excessive precipitates or large phase separations constitutes failure of this test. Slight turbidity, cloudiness, small amounts of precipitates, and/or small phase separations due to antifoam agents of less 0.5% of the total volume of solution are permissible.

3.2.5 Total dissolved solids. The antifreeze shall pass the total dissolved solids test specified herein.

3.2.5.1 Total dissolved solids test Types I and II antifreezes shall contain no greater than 4% total dissolved solids when tested in accordance with Federal Method 2540C, except that a 0.7 micron glass frit filter shall be used instead of the prescribed 0.45 micron filter. Type IP antifreeze shall contain no greater than 2% total dissolved solids when tested in accordance with modified Federal Method 2540C. Total dissolved solids greater than those specified above constitutes failure of this test.

4. REGULATORY REQUIREMENTS.

4.1 Federal Hazardous Substances Act requirements. Under authority of the Federal Hazardous Substances Act, antifreeze containing ethylene glycol shall be labeled in accordance with 16 CFR Part 1500.

5. QUALITY ASSURANCE PROVISIONS.

5.1 Product conformance. The products provided shall meet the salient characteristics of this commercial item description, conform to the producer's own drawings, specifications, standards, and quality assurance practices, and be the same product offered for sale in the commercial market. The Government reserves the right to require proof of such conformance. The contractor shall furnish Certificates of Compliance with all the requirements specified herein, and a certificate that shall be supported by actual test reports from independent source(s) for the antifreeze formulation offered.

6. PACKAGING. Preservation, packing, and marking shall be as specified in the contract or order.

7. NOTES.

(This section contains information of a general or explanatory nature which may be helpful, but is not mandatory.)

7.1 Government documents. Copies of 16 CFR Part 1500 are available from the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402. Copies of Federal Method 2540C are available from the American Public Health Association, 1015 15th Street, N.W., Washington, D.C. 20005.

7.2 Non-Government documents. The ASTM standards referenced herein are available from the American Society for Testing and Materials (ASTM), 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

7.3 Cross-referenced data. Antifreeze meeting this CID's requirements replace and are interchangeable with the following CID, and the two detail specifications for antifreeze used by the federal and military services: CID A-A-870A, MIL-A-46153C, and MIL-A-11755E, dated January 8, 1987, 5 August 1991, and 24 January 1994, respectively.

7.4 Acquisition data. Acquisition documents must specify the following:

a. Title, number, and date of this CID.
b. Issue of the Department of Defense Index of Specifications and Standards (DoDISS) to be cited in the solicitation.
c. Type of antifreeze.
d. Selection of applicable packaging requirements.

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